



# An Overview of the Recent Progress of UCF's CubeSat Program

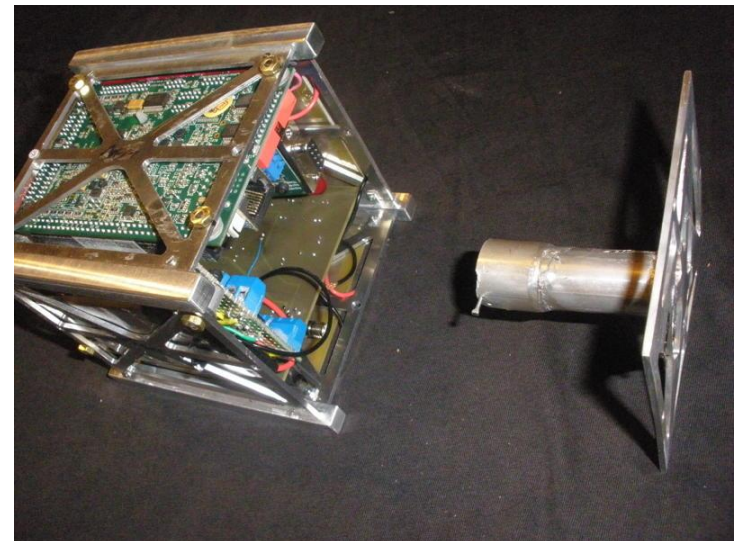
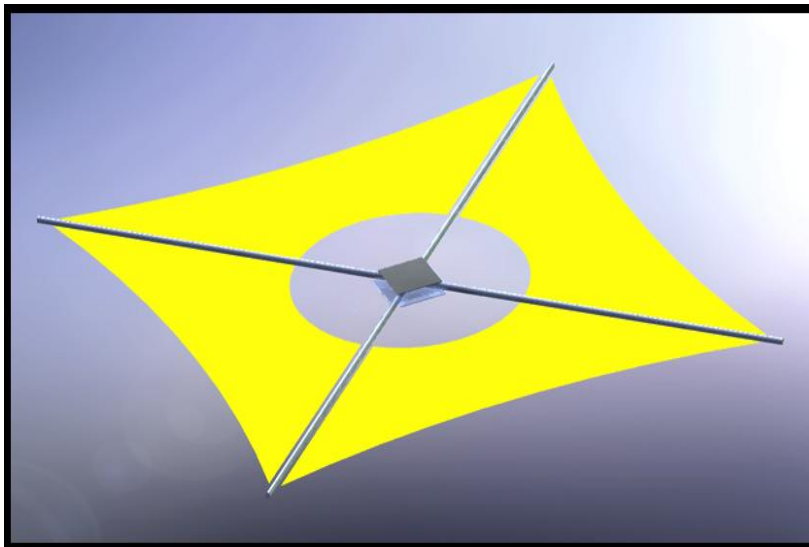
AMSAT Space Symposium  
Oct. 26-28, 2012

Jacob Belli  
Brad Sease

Dr. Eric T. Bradley  
Dr. Richard Eastes  
Dr. Yunjun Xu  
Dr. Kuo-Chi Lin

# Outline

- Past Projects
  - Senior Design (most recent)
    - IonicKnight
    - [Knight]<sup>3</sup>
  - University NanoSatellite Program
    - KnightSat II
- Current Project
  - Dust Detector Mission





# IKNIGHT13

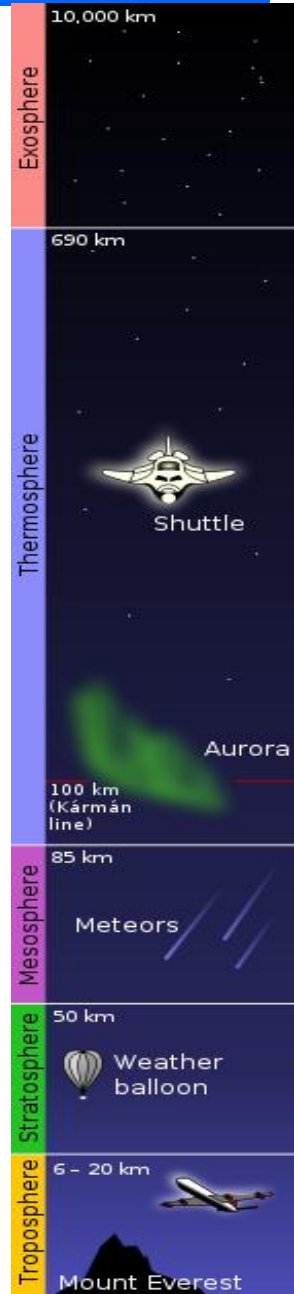






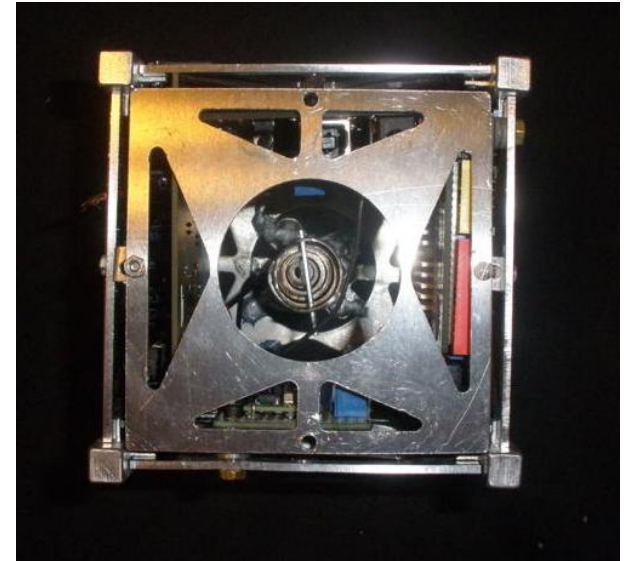
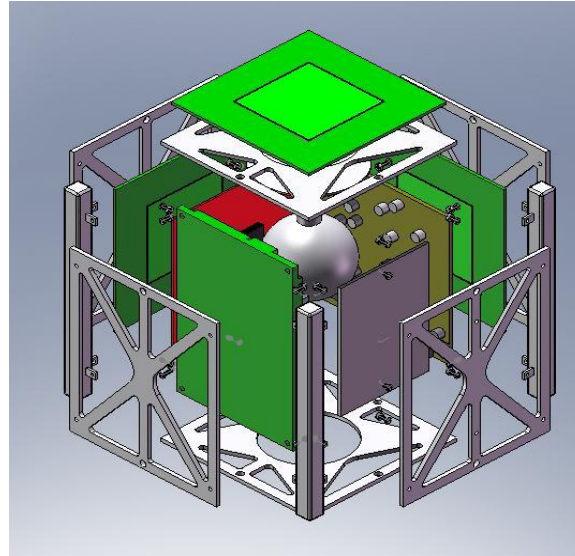
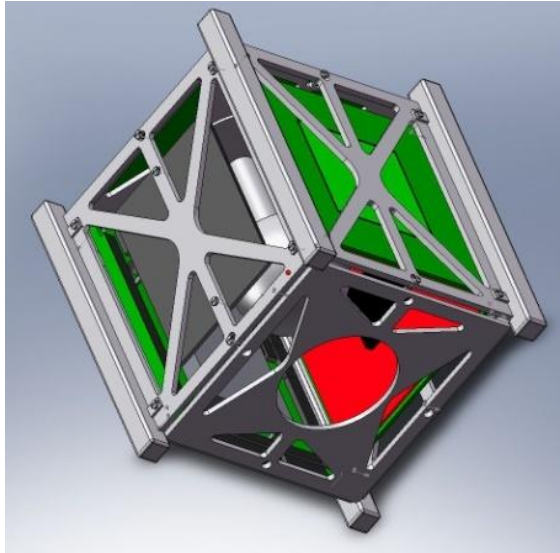
# Mission: Langmuir Probe

- Mission
  - Gather important atmospheric data from 650 km, Sun-Synchronous orbit
  - Effects of specific solar activity on the Earth's climate
- Langmuir Probe: Used to determine the electron temperature, electron density, and electric potential of plasma in the Ionosphere.
- The ionosphere (85-600 km) influences radio propagation and GPS signals, and is responsible for auroras.





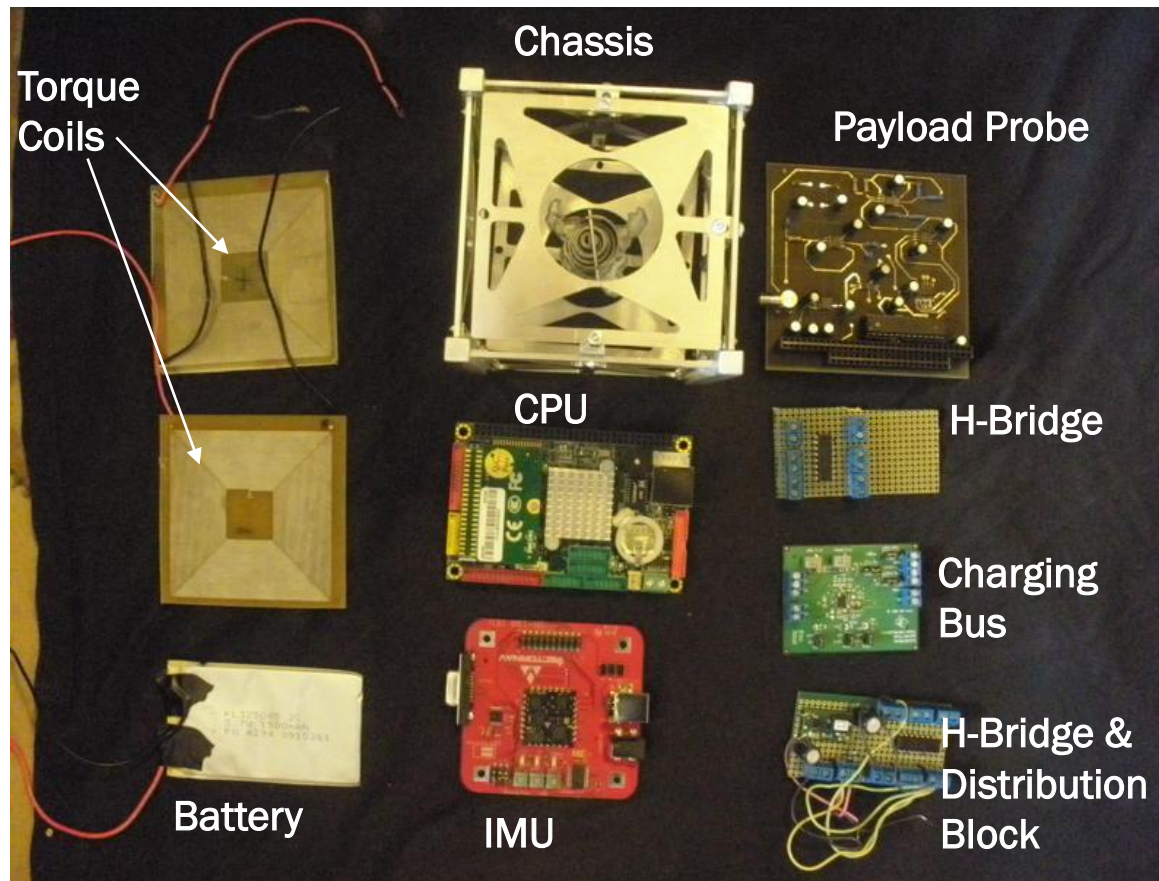
# Structure - Prototype



| Component        | Mass [grams] |
|------------------|--------------|
| Torque coils (3) | 66           |
| Battery          | 31           |
| Circuits         | 95           |
| CPU              | 87           |
| IMU              | 47           |
| Chassis          | 208          |
| Payload probe    | 77           |
| <b>Total</b>     | <b>611</b>   |

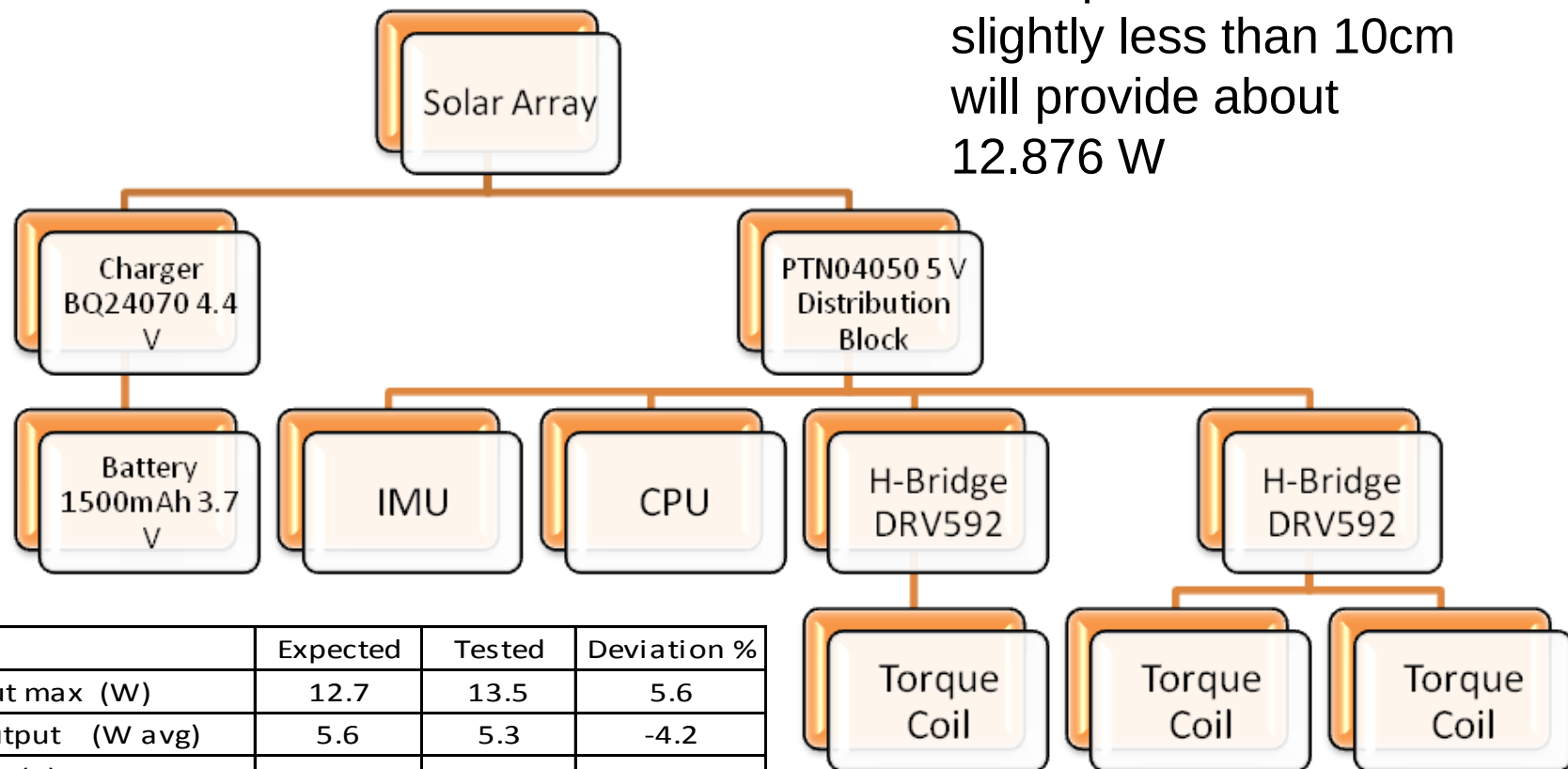
# Structure - Hardware

- Hardware was fastened to the faces of the CubeSat



# Power Subsystem

Solar panel size of slightly less than 10cm will provide about 12.876 W

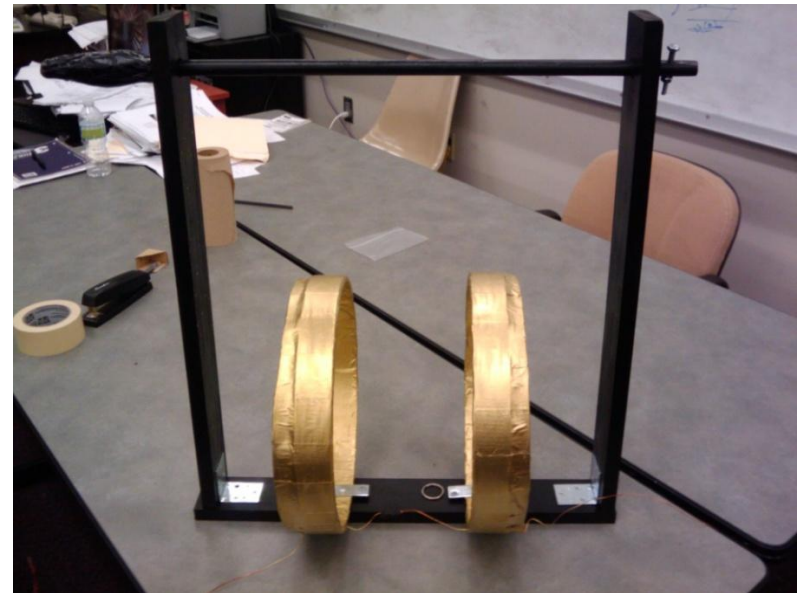
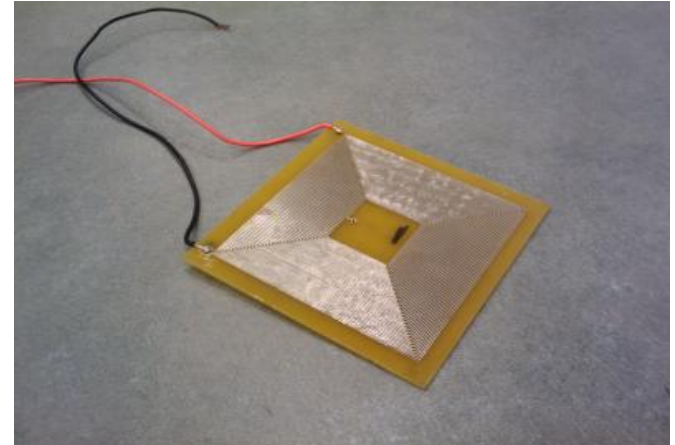


|                        | Expected | Tested | Deviation % |
|------------------------|----------|--------|-------------|
| Solar input max (W)    | 12.7     | 13.5   | 5.6         |
| Battery output (W avg) | 5.6      | 5.3    | -4.2        |
| Bus output (V)         | 4.4      | 4.2    | -4.8        |
| Voltage Reg (V)        | 5.0      | 4.9    | -2.0        |
| Solenoid input (V)     | 2.5      | 2.3    | -8.7        |
| Charging time (Min)    | 63.0     | 56.0   | 12.5        |

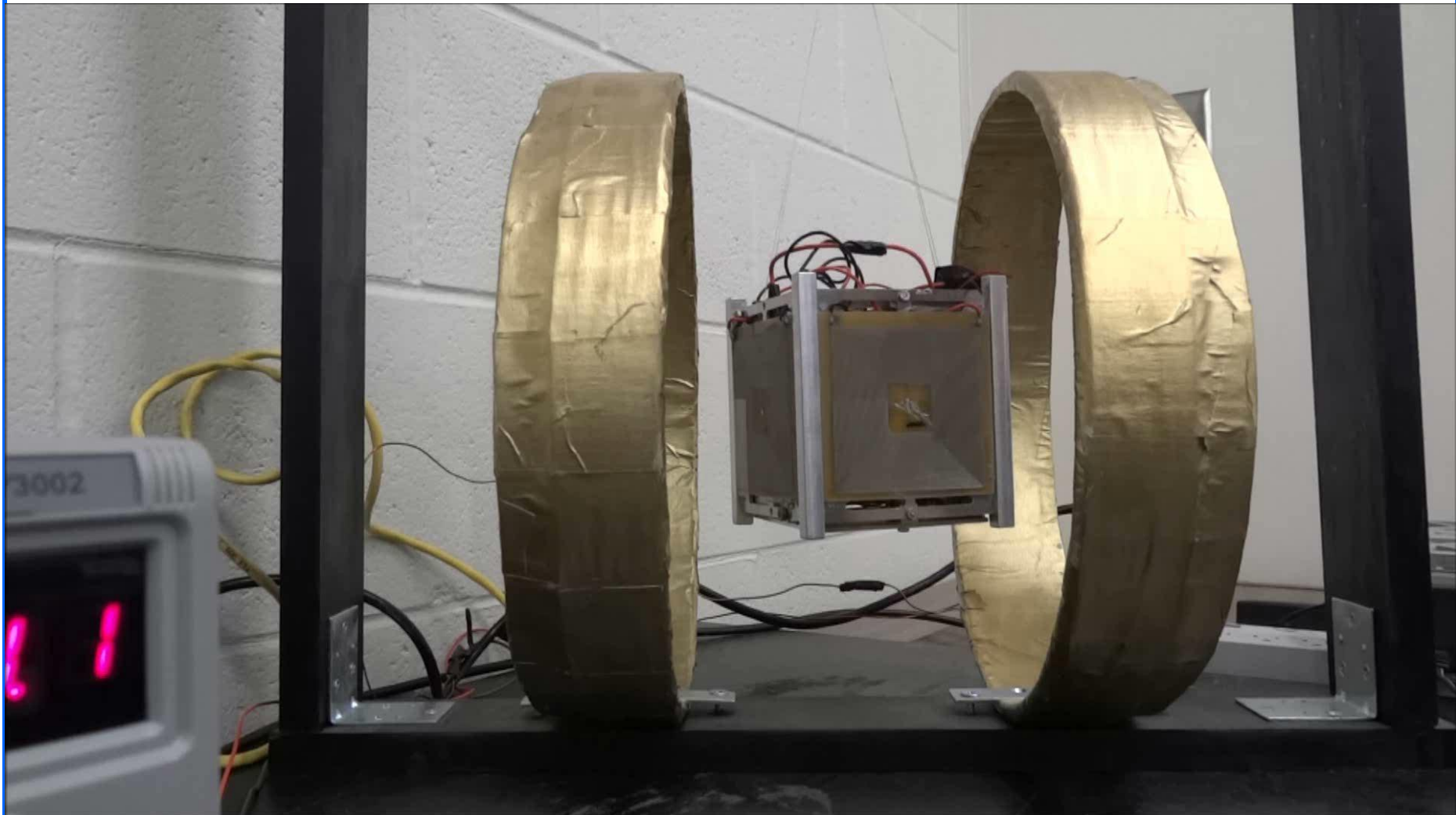


# ADCS - Overview

- Satellite attitude controlled by three torque coils
- Gravity gradient boom used to aid in pointing
- VectorNav IMU capable of 200 Hz update rate









# IonicKNIGHT CubeSAT

University of Central Florida

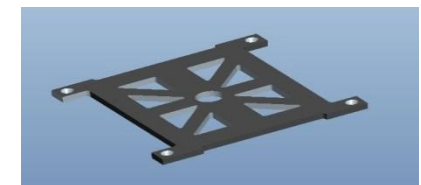
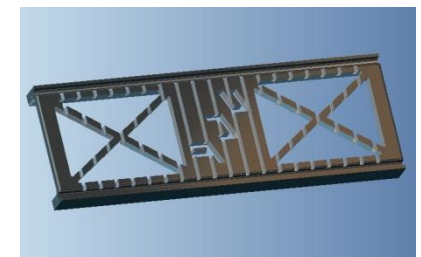
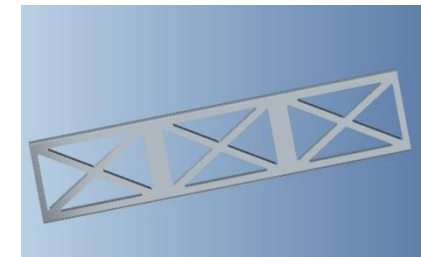
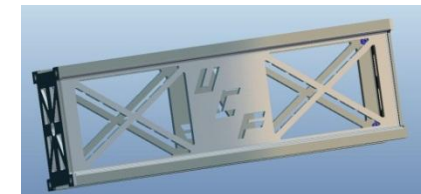
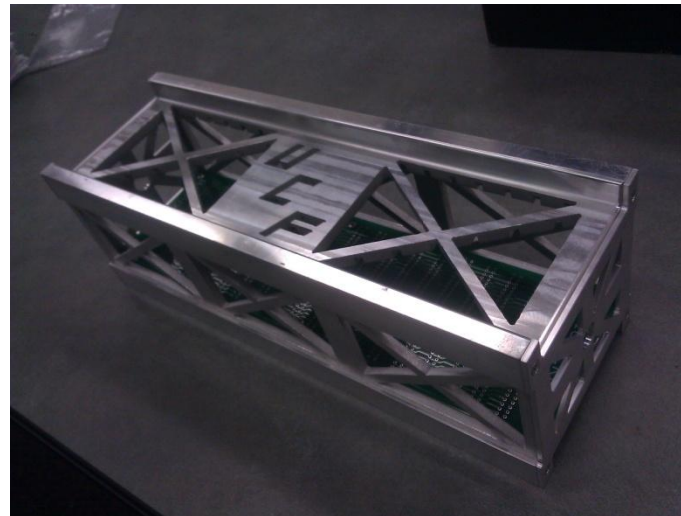




# Structural Design



- Structural Design
  - 30x10x10 cm
  - 1.05 kg frame
  - AL6061



| Part          | Quantity | Weight (g) |
|---------------|----------|------------|
| Slotted Panel | 1        | 464.58     |
| Thick Panel   | 1        | 497.99     |
| Side Profile  | 2        | 9.46       |
| Top Panel     | 2        | 80.76      |
|               | TOTAL    | 1052.80    |

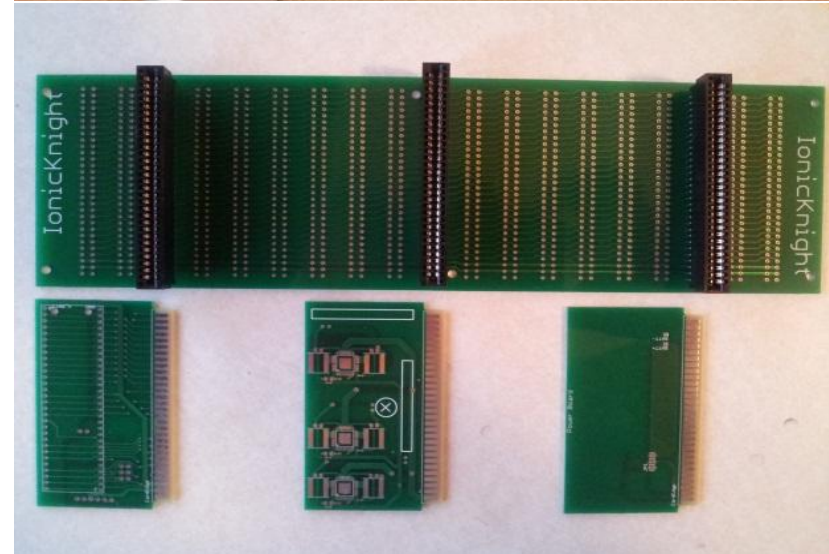
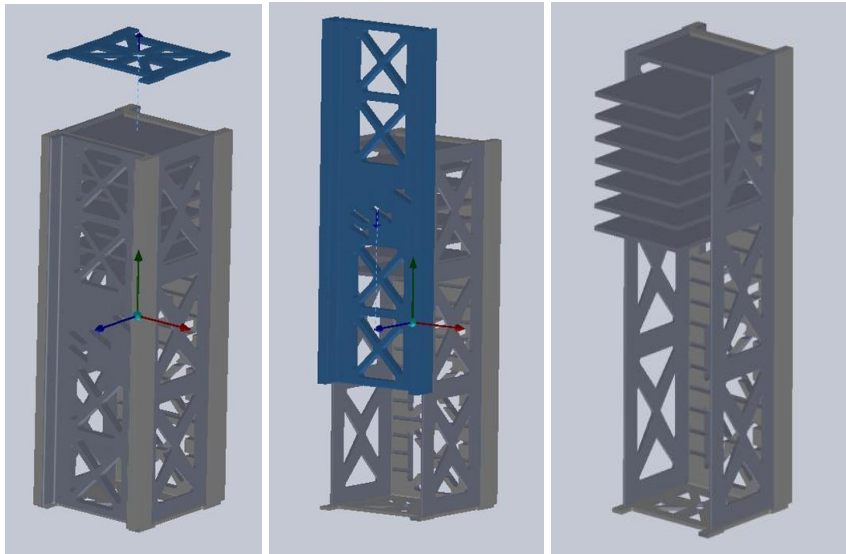
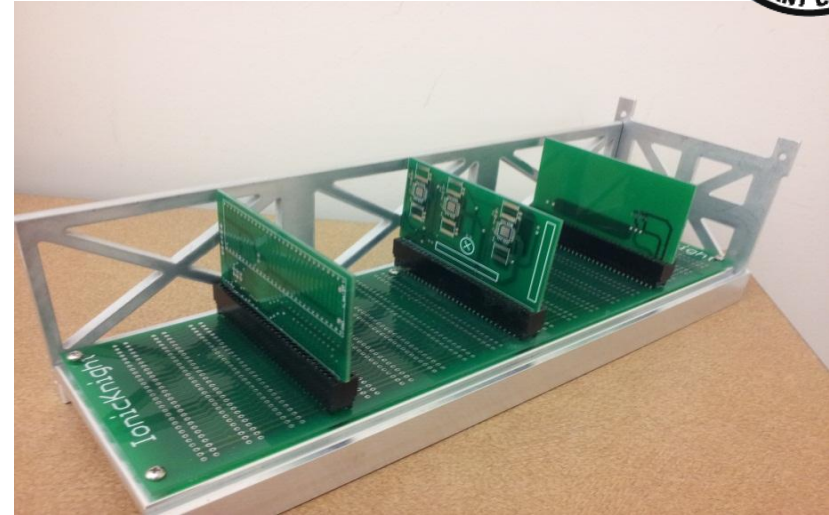




# Interior Design



- Blade Design
  - Use Printed Circuit Boards (PCB) to decrease wiring and volume used
  - Can be used with an array of missions
  - Easily Installed/Replaced
  - Main board has 19 slot positions
  - Each slot has 2 rows of 30 pins
  - All pin positions are connected in parallel
  - Allows for independent card positioning

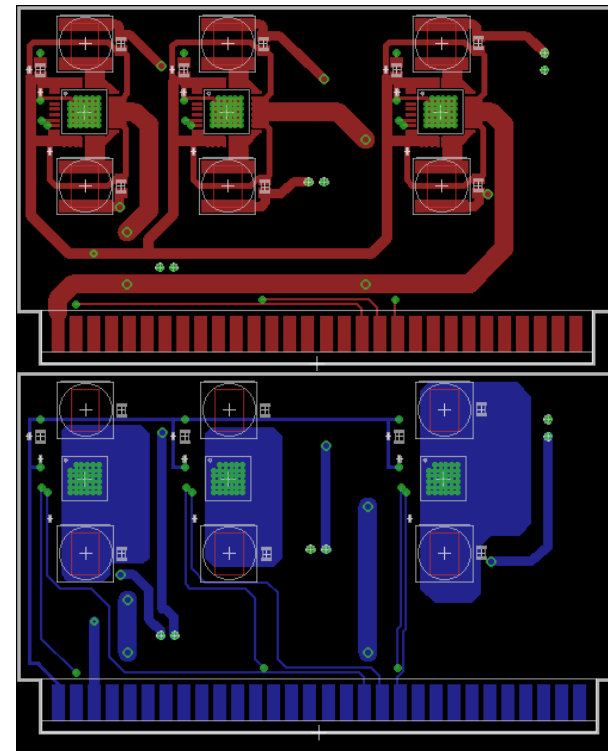
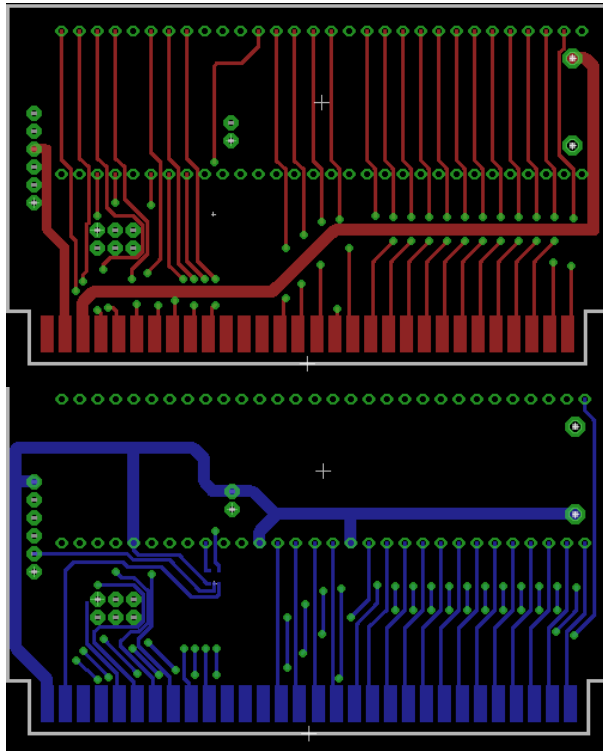




# Electrical Design



- CPU/IMU Board
  - IMU and CPU share same slot board
  - IMU outputs logic at 3.3V
  - CPU handles logic at 1.8V
  - CPU outputs PWM signals for Torque Rods on separate board
- Torque Rod Control Board
  - Torque Rods controlled using on chip H-Bridge amplifier
  - Special care taken designing the PCB layout
    - Trace length
    - Thermal panes
    - Component distances and spacing





# Helmholtz Coil Design



- Each coil capable of independent control using an H-Bridge circuit controlled by an Arduino through Matlab
- The Helmholtz Coil is capable of creating a 10 Gauss magnetic field in X, Y, & Z directions independently
  - X Coils: 0.48m diameter, 121 turns
  - Y Coils: 0.51m diameter, 129 turns
  - Z Coils: 0.54m diameter, 137 turns







# The Development of a Propellantless Navigation and Attitude Control Drag Sail for LEO Satellites



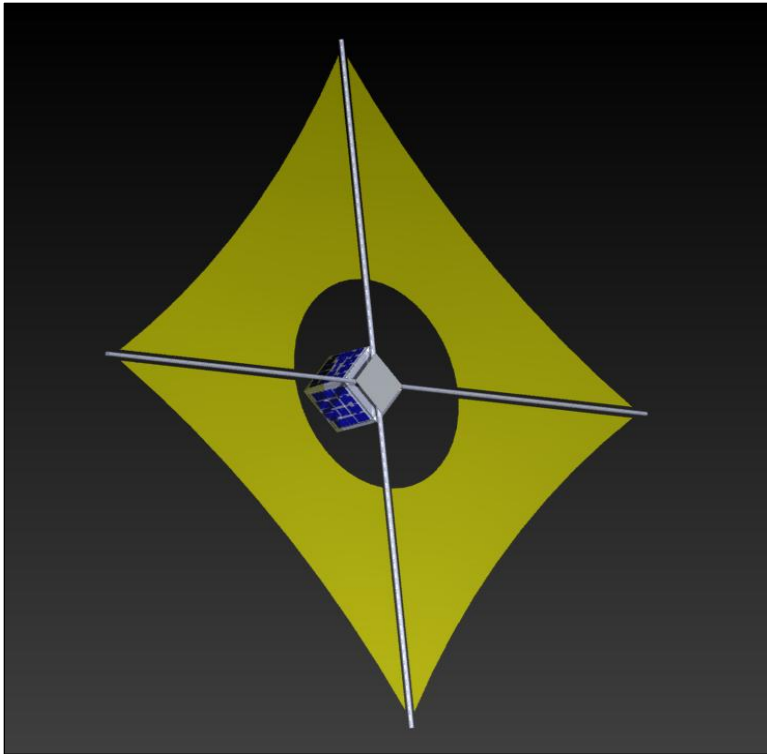


# University Nanosatellite Program

- Satellite design and fabrication competition for universities sponsored by Air Force Research Laboratory (AFRL) through AFoSR.
- UCF is one of the 11 universities selected to participate in the competition.
- Other universities include MIT, Georgia Tech., Cornell, University of Minnesota, etc.
- About 10 students participated from the beginning to the end, and roughly 15 more students participated at various stages of the project. They come from
  - Aerospace Engineering, Mechanical Engineering, Electrical Engineering, Computer Engineering, Computer Science, Civil Engineering
- Several subsystems have been the subjects of the senior design projects.



# Mission Requirements

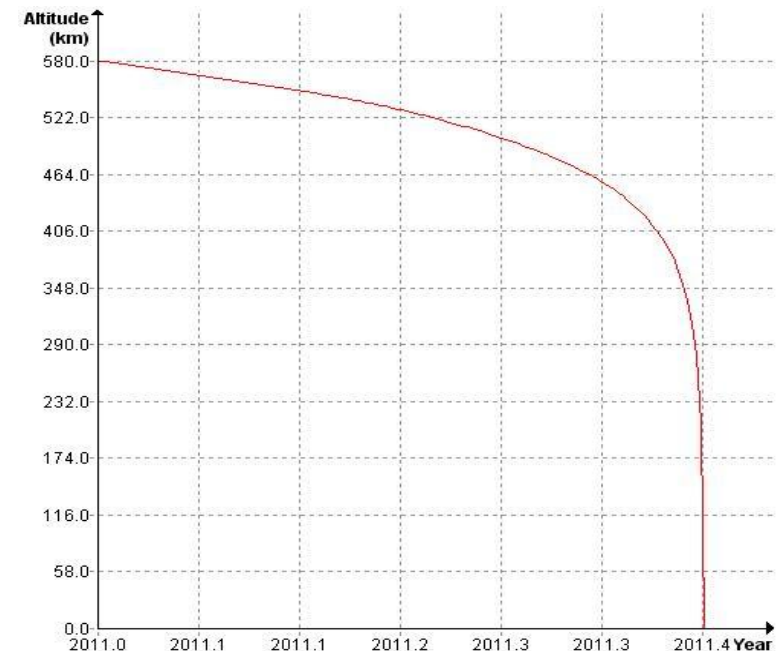
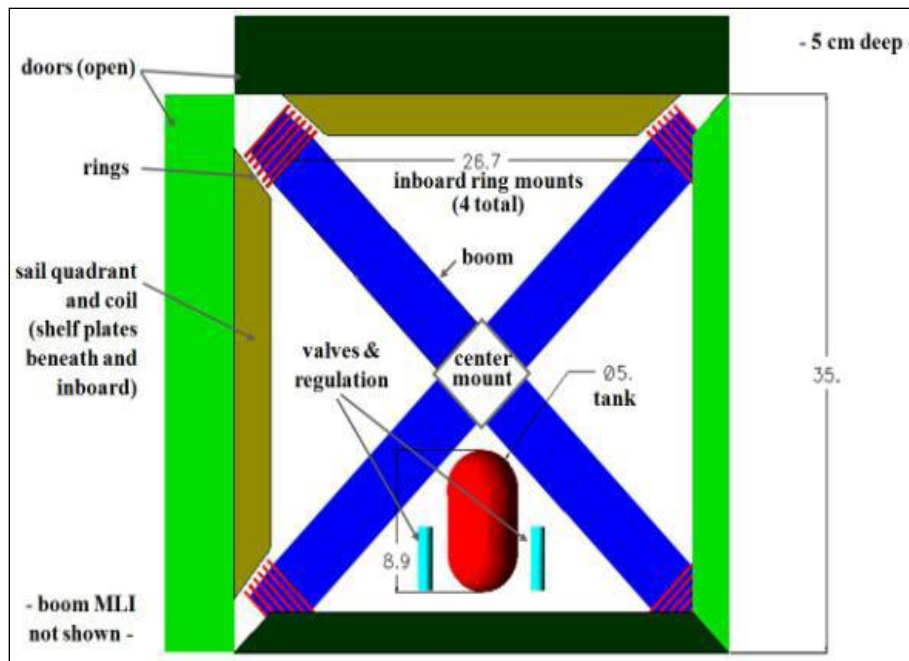


- Design and build a deployable gossamer sail with magnetic coils for the propellantless navigation and attitude control system of a LEO nanosatellite.
- Demonstrate and validate the sail system for propellantless orbital maneuvering, and attitude control

|        |                                                                                         |        |
|--------|-----------------------------------------------------------------------------------------|--------|
| SR-1-1 | KnightSat II must deploy gossamer sail by way of C&DH after stabilization               | MR-1-1 |
| SR-1-2 | ADCS must control ACADS and provide attitude control capabilities of $\pm 10^\circ$     | MR-1-2 |
| SR-1-3 | Satellite must survive a minimum of 12 months and provide health monitoring information | MR-1-1 |

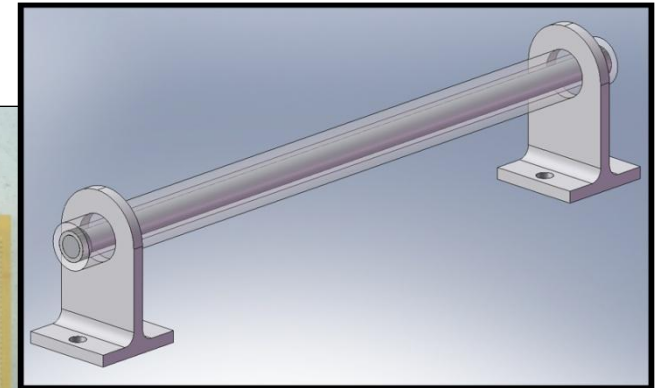
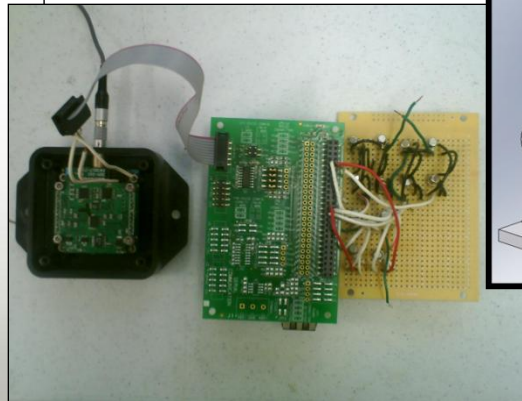
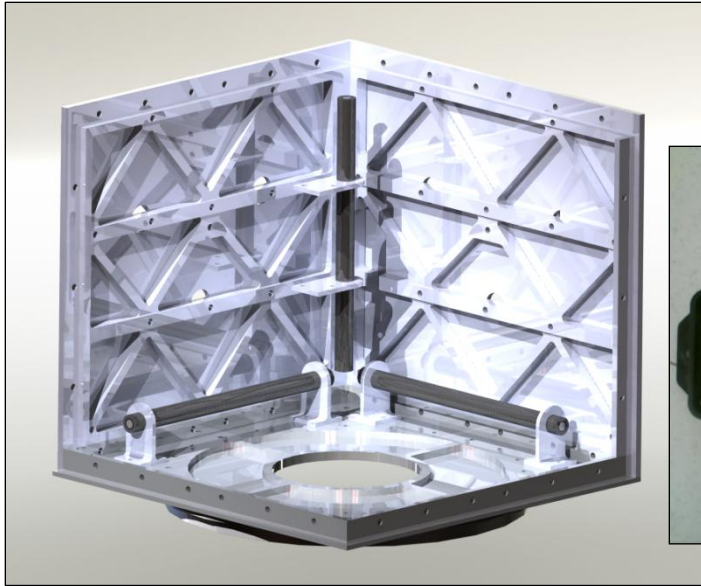


# Attitude Control & Aerodynamic Drag Sail (ACADS)



- Maintains the ability to reverse current direction through the ACAD's torque coil to provide attitude control
- Has a large enough cross section to be easily monitored with a NORAD TLE
- Simulation shows the ACADS de-orbits the satellite from 580km in under 6 months

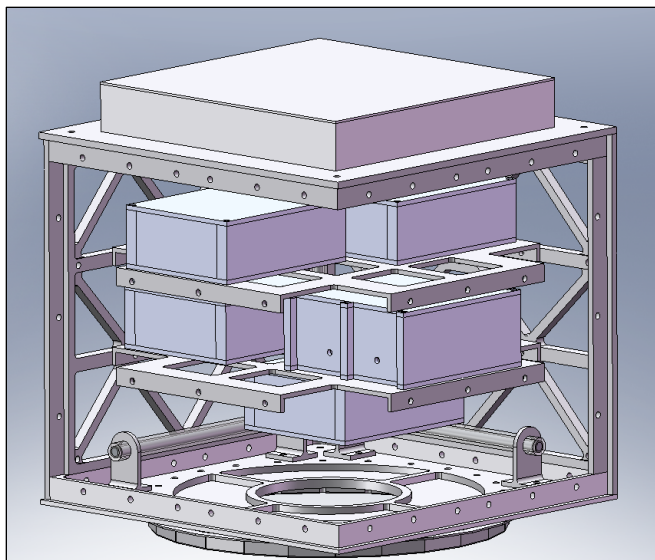
# Attitude Determination and Control System



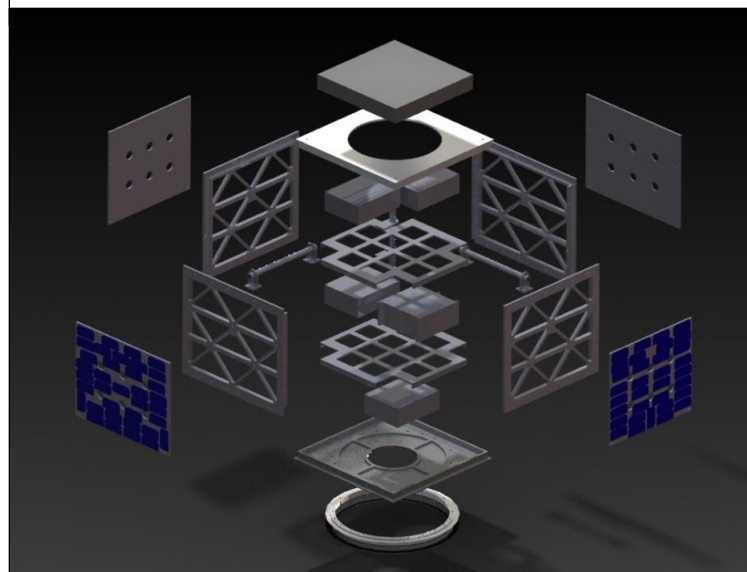
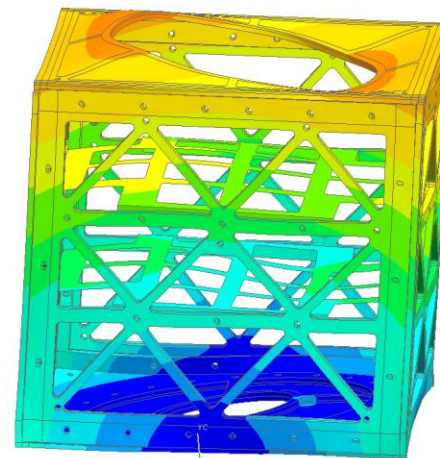
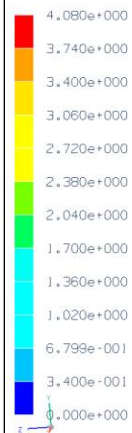
- Active magnetic control provides initial stabilization for deployment of ACADS
- ADCS will turn over partial attitude control to ACADS
- Overall pointing accuracy is +/- 10 degrees



# Structure



nano\_sat\_sim1 : Modal\_103 Result  
Load Case 1, Mode 3, 1.634e+002 Hz  
Displacement - Nodal, Magnitude  
Min : 0.000e+000, Max : 4.080e+000, in  
Deformation : Displacement - Nodal  
Animation Frame 7 of 8





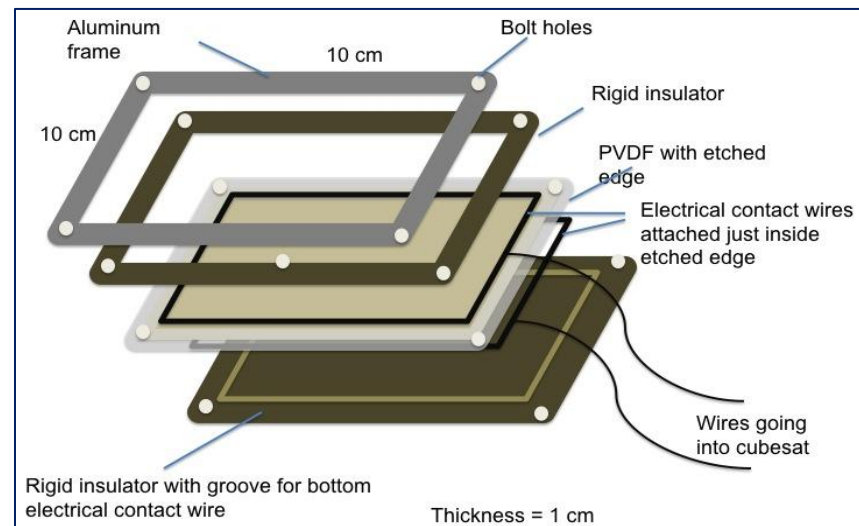
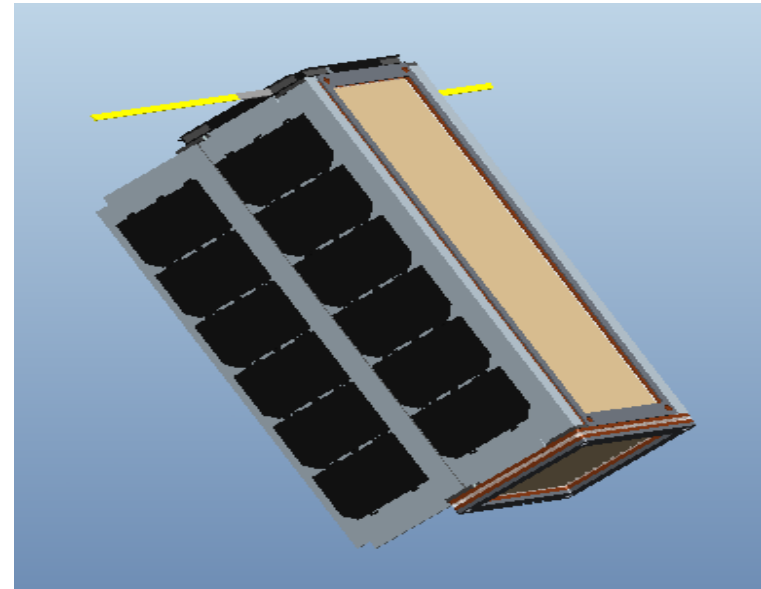


# Low Cost Dust Detector for Low Earth Orbit



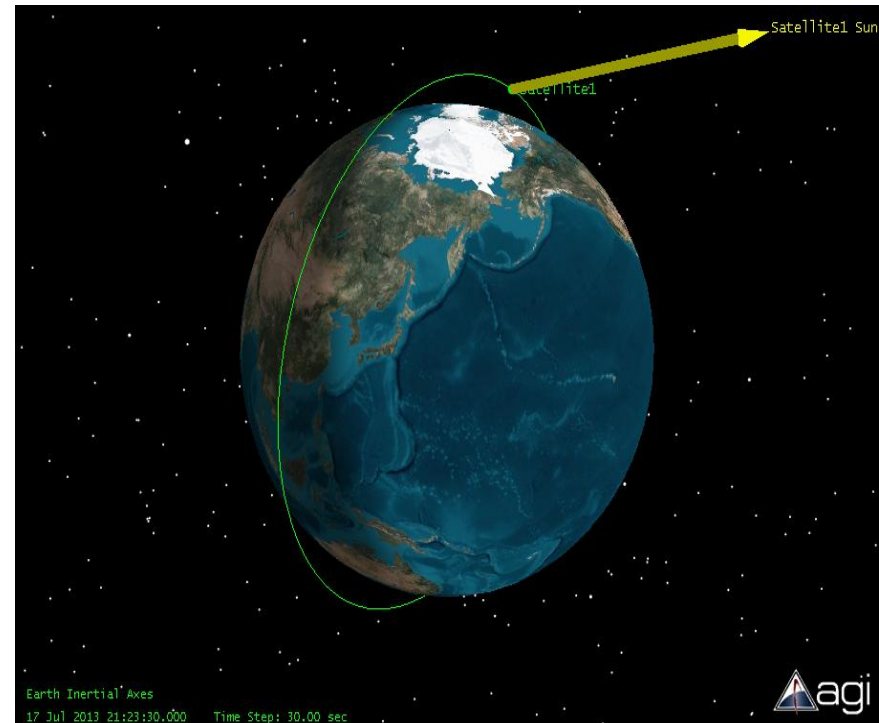
# Payload

- Dust Detector
  - 10x10x0.1cm
  - 1 W current power estimate
- Purpose: Determining the quantity of particles present in LEO (Low Earth Orbit)
- Mission time: 1 year
- Very thin, will be attached to outside of satellite
- Specific properties of Dust Detector still in testing phase
- Thermal cycling issues



# Orbit

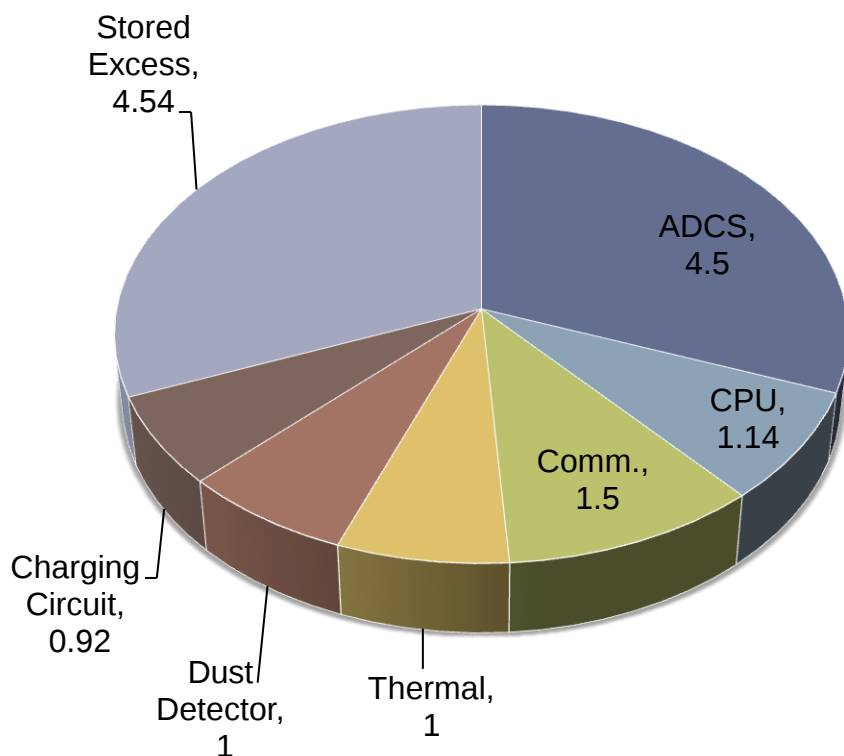
- Circular, Sun-Synchronous Orbit
  - Inclination =  $98.4^\circ$
  - Altitude = 750 km
  - Period = 99 min
- Benefits:
  - Continual solar exposure
  - Minimizes battery use
  - Eliminates thermal cycling
- Orbital degradation after 4 months leading to orbital eclipses of 20 minutes max
- Occasional lunar eclipses





# Subsystem Estimates

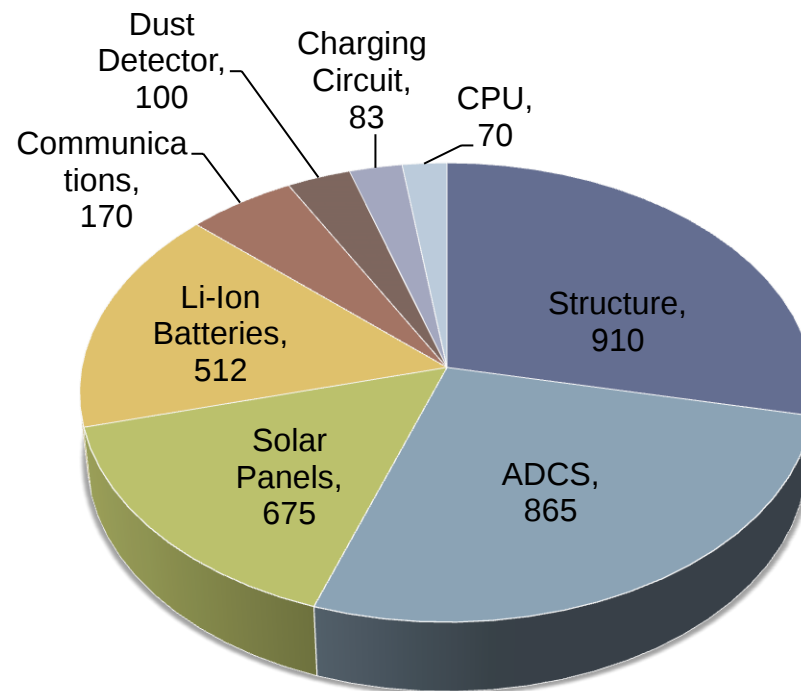
## Maximum Power Budget (W)



Total Power Available = 14.6 W

Peak Power Consumed = 10.06W

## Mass Budget (g)



Total Mass = 3.315 kg

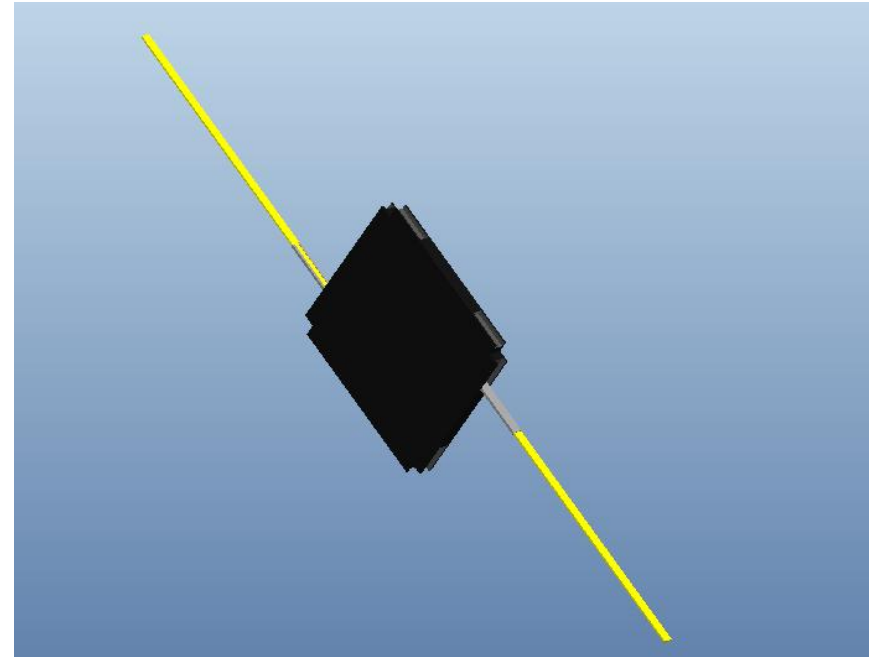


# Satellite Run Modes

| Dead-Launch Mode                            | Pointing Mode                                                                                             | Data Collection Mode                                                                                                                                                                                                  |
|---------------------------------------------|-----------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <i>All systems separated from batteries</i> | <i>Establish payload pointing and solar panel pointing</i><br><br><i>Non-critical subsystems disabled</i> | <i>Maintain payload and solar panel pointing</i><br><br><i>Collect science and telemetry data</i><br><br><i>CPU in low-power mode for minor data handling</i><br><br><i>Transmit to ground in 30 second intervals</i> |
| Active Systems: <b>None</b>                 | Active Systems:<br><b>CPU: 1.14 W</b><br><b>ADCS: 4.5 W</b><br><b>Charging Circuit: 0.9 W</b>             | Active Systems:<br><b>CPU: 0.13 W</b><br><b>ADCS: 1.5 W</b><br><b>Charging Circuit: 0.9 W</b><br><b>Comm.: 0.25 W</b><br><b>Thermal: 1 W</b><br><b>Payload: 1 W</b>                                                   |
| Peak Power ~ 0 W<br>Average Power ~ 0 W     | Peak Power ~ 6.54W<br>Average Power ~ 6.54W                                                               | Peak Power ~ 10.06 W<br>Average Power ~ 4.78 W                                                                                                                                                                        |

# Communications

- ISIS UHF Transmitter: 400-450 MHz, 1200 bps
- ISIS Deployable Antenna: Dipole, 30 cm total length
- Transmit every 30 seconds to ensure that a downlink occurs within communication access window
- Transmit telemetry data along with archive of recent detections





# Development Plans

- Purely theoretical research has been done up to this point
  - Most of the chosen hardware components are awaiting funding
- More in depth modeling and analysis is planned in the near future



# Acknowledgments

- [Knight]<sup>3</sup>
  - Yash Joshi
  - Luis Ayalde
  - Matthew Kieselbach
  - Jorge Pastrana
- IonicKnight
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  - Henry Cabrera
  - Jesse Carreiro
  - Matt Cole
  - Kyle Houser
- KnightSat II
  - Michael Pfisterer
  - Kevin Schillo
  - Christopher Valle
  - Et Al
- Also, thanks to FSGC, AFRL, and SRI for continued support